Integrated Ceramic Matrix Composite and Carbon/Carbon Structures for Large Rocket Engine Nozzles and Nozzle Extensions, Phase I

Completed Technology Project (2012 - 2012)

Project Introduction

Low-cost access to space demands durable, cost-effective, efficient, and low-weight propulsion systems. Key components include rocket engine nozzles and nozzle extensions for boost and upper stages. Options for such nozzles include actively cooled alloys, ablatives, and radiation-cooled composites and metals, each of which has known limitations. Actively cooled structures are complex and costly. Ablatives are heavy and limit performance due to shape instability. Radiation-cooled composites are costly, have a limited production base, and are size-limited. Radiation-cooled metals face low temperature limits, require significant machining for acceptable weight, and require protective coatings. These limitations are highlighted by the J-2X nozzle extension, which uses a highly machined metallic structure to minimize weight and requires an emissivity coating to maintain safe operating temperature. Carbon/carbon (C/C) provides an attractive alternative, but has joining ability, oxidation resistance, and manufacturability limitations. Ultramet previously developed and demonstrated carbon fiber-reinforced refractory ceramic matrix composites (CMC) for liquid propellant applications up to 4300¿F. Ultramet has also demonstrated the integration of lightweight C/C with CMCs in a unique system comprising a C/C primary structure with an integral CMC liner or jacket. This system bridges the weight and performance gap between C/C and CMCs. The CMC provides enhanced mechanical properties and environmental resistance while the C/C provides a lightweight and cost-effective structure. In this project, the feasibility and benefits of applying this integrated material system for large liquid rocket engine nozzles will be validated. Subsequent work will address scaleup and will include a C/C producer. The fully developed system will combine the low weight and cost-effectiveness of C/C with the strength and durability of CMCs to support a range of potential NASA missions.

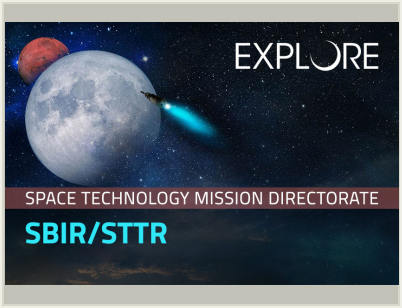

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Table of Contents

Small Business Innovation Research/Small Business Tech Transfer

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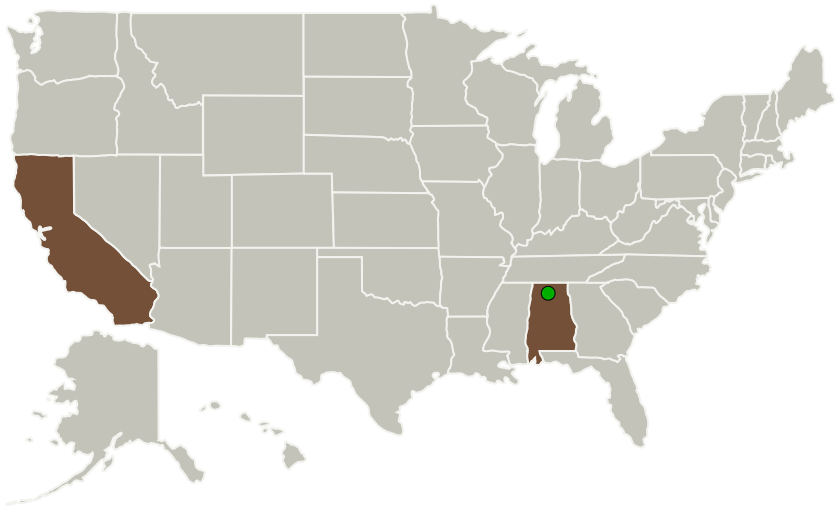
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Ultramet	Lead Organization	Industry	Pacoima, California
Marshall Space Flight Center(MSFC)	Supporting Organization	NASA Center	Huntsville, Alabama

Primary U.S. Work Locations	
Alabama	California

Project Transitions

February 2012: Project Start

August 2012: Closed out

Closeout Documentation:

- Final Summary Chart*(https://techport.nasa.gov/file/138666)*

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Ultramet

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

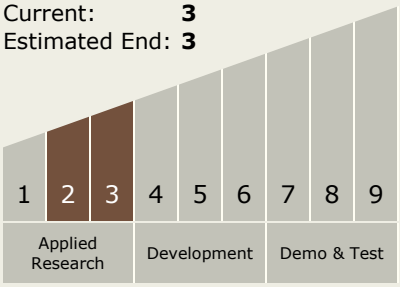
Carlos Torrez

Principal Investigator:

Matthew J Wright

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



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Completed Technology Project (2012 - 2012)

Technology Areas

Primary:

- TX01 Propulsion Systems
  - TX01.1 Chemical Space Propulsion
    - TX01.1.3 Cryogenic

Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System